Towards subseasonal predictions of extreme heat

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Australian Government
Bureau of Meteorology

CSIRO

Increasing demand

Improving subseasonal predictions (Oct 2009-Sept 2012)

Subseasonal prediction of heat extremes (Jan 2012-Dec 2014)

CliMag

Edition 18 December 2009

Multi-week forecasts will help bridge the gap

When it comes to weather and climate forecasts, farmers will take all the information they can get.

Forecasts currently available to farmers tell them about the specific weather in the week ahead, or the expected climate for the full 3-month season ahead. But more detail about expected variations in weather in the fortnight or month ahead would help farmers make better farm management decisions.

Susan Carn and her husband manage a dryland merino sheep farm with occasional wheat and barley crops in Quorn in South Australia's Flinders Ranges. Being totally reliant on rainfall, every decision they make hedges on predicting how much rain will fall, and when.

Susan Carn, Quorn, South Australia

'We're pretty cautious. I start looking at the long-range forecast in March, three months ahead, to see how the season looks like panning out', says Susan. 'We need to decide how much stock to keep or, if it looks promising, we might buy more stock. With crops, if it looks good on the long-range forecast we'll plant some crop and spend money on fertiliser. If it's not looking good, we won't sow much, if any; we're in marginal country, so we have to be conservative.'

There are two main limitations with the traditional suite of forecasts currently available to farmers like Susan Carn:

- The gap between the 7-day weather forecast and the 3-month seasonal forecast limits the planning decisions farmers need to make on a fortnightly or monthly basis.
- Seasonal forecasts are based on historical records, using statistics about past weather patterns to predict what will happen this season. As a result, statistical models do not perform as well when faced with rare or unprecedented conditions, a situation we are increasingly seeing with climate change.

A new forecasting tool in its early stages of development by the Bureau of Meteorology will help overcome these two limitations. Rather than relying on historical weather statistics, the Predictive Ocean Atmosphere Model for Australia (POAMA) uses global circulation models to predict the weather and climate for the coming months.

Forecasters enter information about the current state of the oceans and the atmosphere into the model which then forecasts the probabilities of the weather and climate being different from typical conditions. For example, the model can calculate the chances of the total rainfall for a forecast period being above or below the historical average.

'The advantage of using a global circulation model is that it naturally takes into account changes in the climate because the forecast is based on today's observations of the atmosphere and the ocean', explains Dr Harry Hendon, one of the developers of POAMA.

[continued on page 2]

In this issue

MANAGING CLIMATE VARIABILITY R&D PROGRAM

Anger over spike in deaths during record Victorian heatwave

http://www.theage.com.au/victoria/anger-over-spike-in-deaths-during-record-victorian-heatwave-20140126-31gxb.html

'I was in the middle of the set and then I saw Snoopy': Tennis player relives moment he hallucinated then collapsed on court as deadly heatwave continues across Australia

http://www.dailymail.co.uk/news/article-2539626/Widespread-heatwave-causes-bushfires-court-chaos-Australian-Open.html

16 JAN 2014 - 8:40PM

Heatwave conditions prompt health warning

WORLD NEWS AUSTRALIA

IMAGE | VIDEO | AUDIO

High temperatures across southeast Australia prompt health experts to issue a public warning about the dangers posed by extreme heat.

http://www.sbs.com.au/news/article/2014/01/15/heatwave-conditions-prompt-health-warning

MANAGING CLIMATE VARIABILITY R&D PROGRAM

GRDC Grains Research & Development Corporation

mla MEAT & LIVESTOCK AUSTRALIA

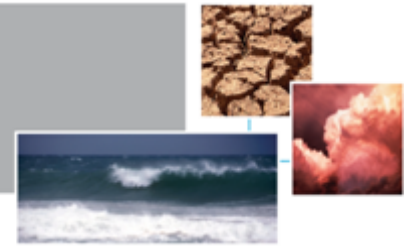
Australian Government

Department of Agriculture, Fisheries and Forestry

Rural Industries Research and Development Corporation

Sugar Research and Development Corporation

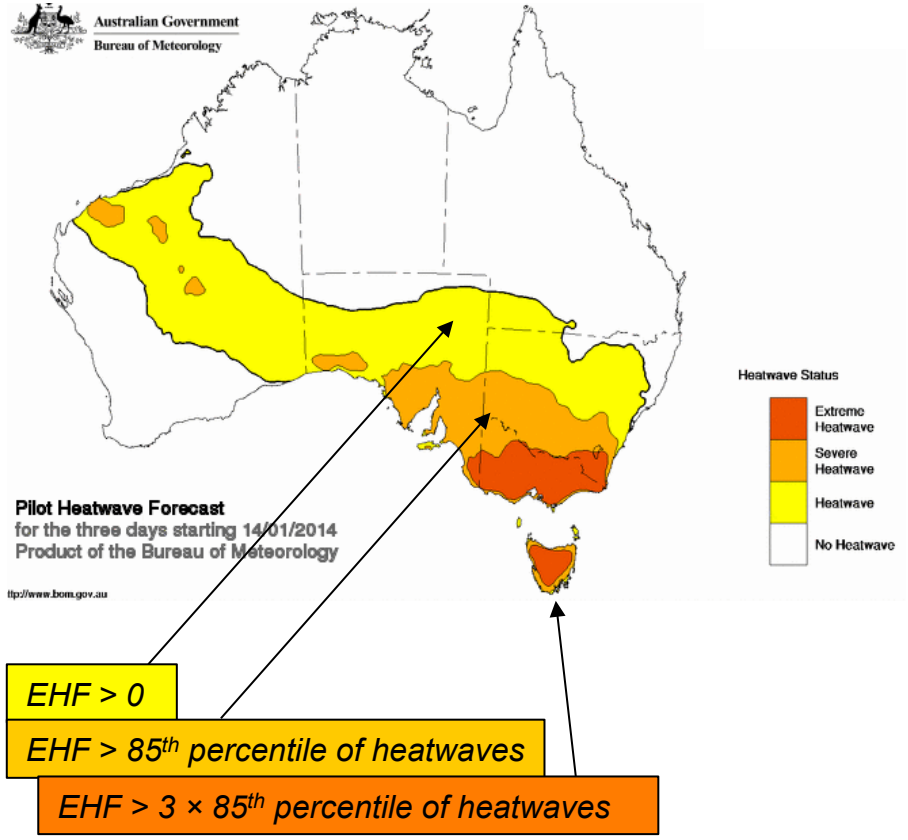
The Bureau of Meteorology's weather forecast heatwave service



Excess Heat Factor (EHF), Nairn and Fawcett 2013

http://www.cawcr.gov.au/technical-reports/CTR_060.pdf

Comprised of the significance excess heat index (EHI_{sig})
and the acclimatisation index (EHI_{accl})



Three days or more of high maximum and minimum temperatures that are unusual for that location (> climatological 95th percentile)

$$EHI_{sig} = (T_i + T_{i+1} + T_{i+2})/3 - T_{95}$$

The degree of acclimatisation, compared to the previous 30-day average (positive EHI_{accl} suggests lack of acclimatisation)

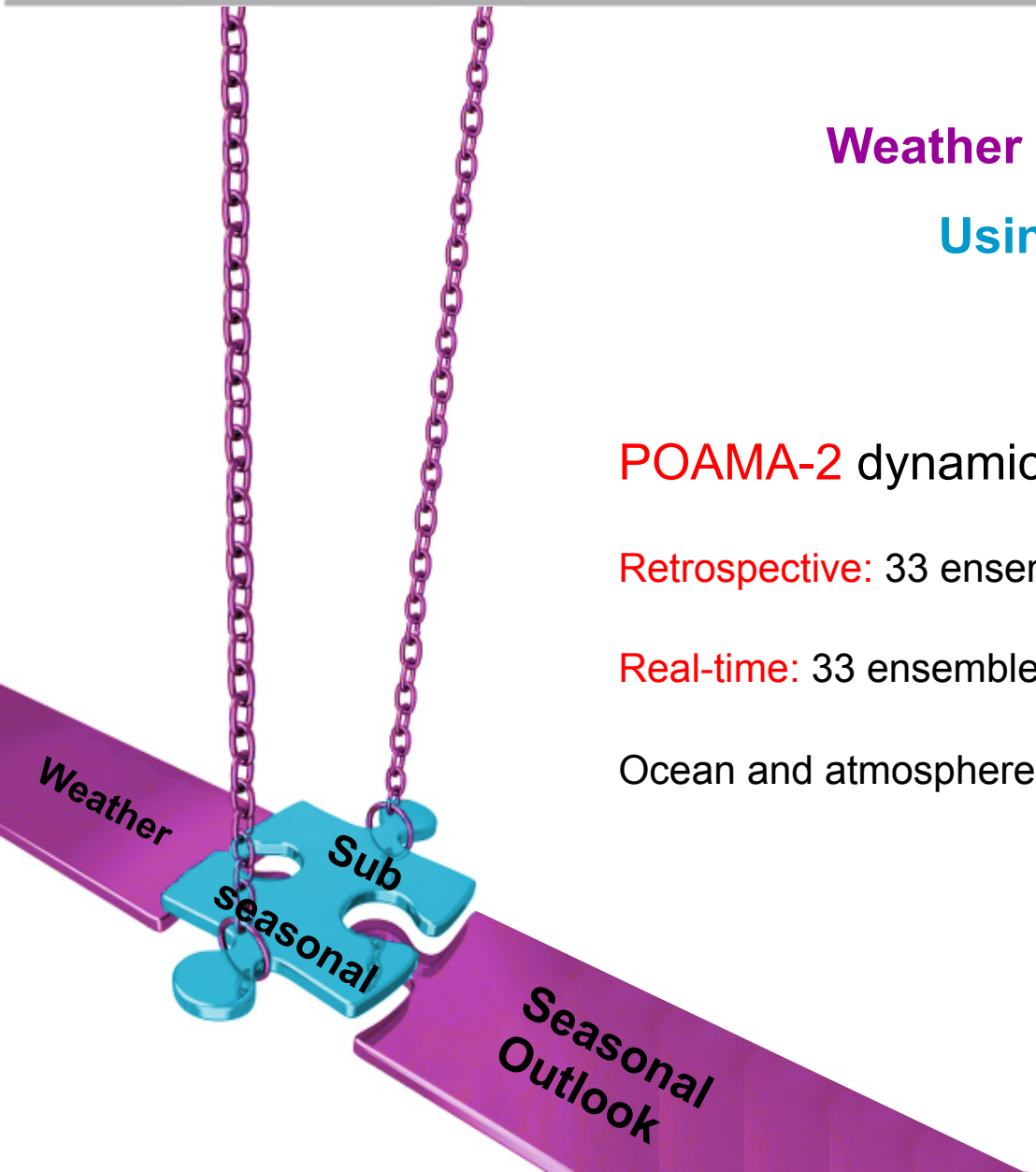
$$EHI_{accl} = (T_i + T_{i+1} + T_{i+2})/3 - (T_{i-1} + \ldots + T_{i-30})/30$$

$$EHF = EHI_{sig} \times \max(1, EHI_{accl})$$

EHI_{accl} > 1 will amplify the EHF index value

http://www.bom.gov.au/australia/heatwave

Prediction



Weather and climate forecasts for risk management

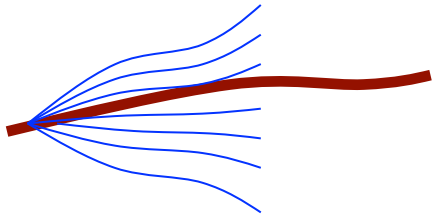
Using POAMA/ACCESS to help fill the gap

POAMA-2 dynamical subseasonal-to-seasonal prediction

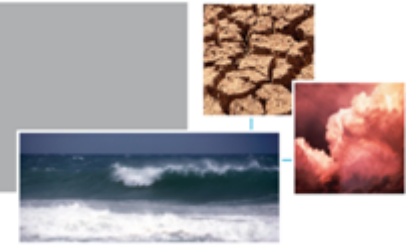
Retrospective: 33 ensemble members on 1st, 11th & 21st of month, 1981-2013

Real-time: 33 ensemble members twice per week since 2012

Ocean and atmosphere perturbations from Coupled Ensemble Initialisation Scheme (breeding)



Application to subseasonal heatwave forecasts



Monthly/Seasonal forecasts

- Update contingency plans, train volunteers
- Sensitize community, enable early-warning system

Multi-week forecasts

- Mobilize assessment team, alert volunteers
- Warn community, local preparation activities

Weather (NWP) forecasts

- Activate volunteers
- Evacuate community

Adapted from iri.columbia.edu/csp/issue3/download

Probability (percentage of ensemble members) of low-intensity/severe/extreme heatwaves occurring at any time within weeks/fortnights/month ahead

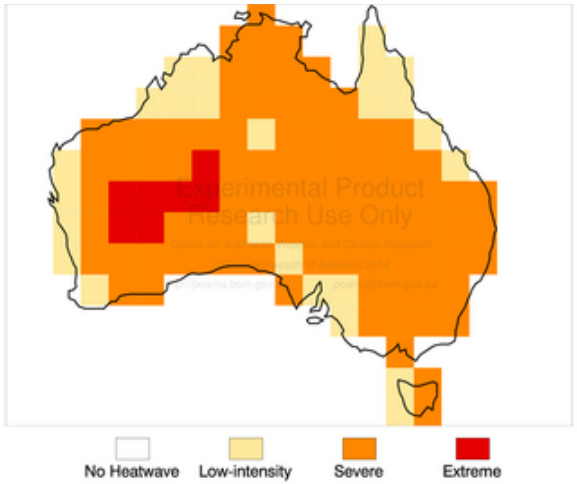
POAMA-2 has generally good skill in detecting heatwaves at all lead times (Hudson and Marshall 2016, Bureau Research Report in review)

Experimental heatwave forecast product, e.g. January 2013

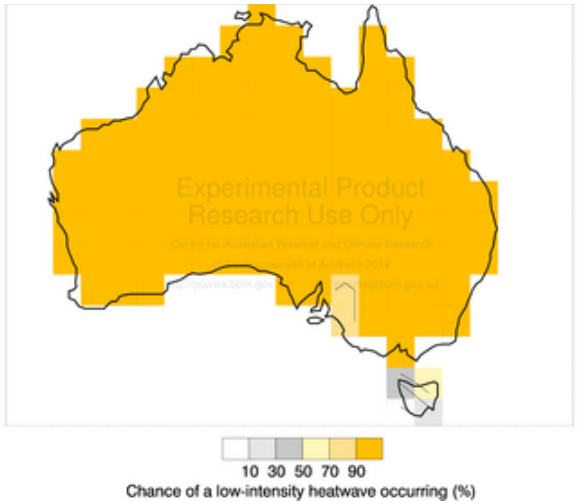
POAMA EHF heatwave probability forecast for January 2013

Month 1 (Initialised 27 December 2012)

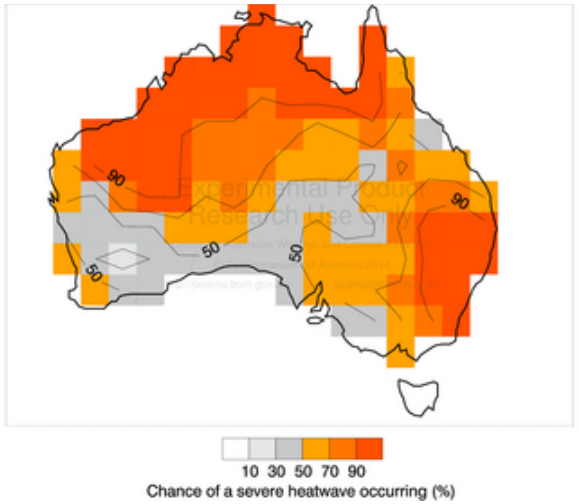
OBSERVED (AWAP)



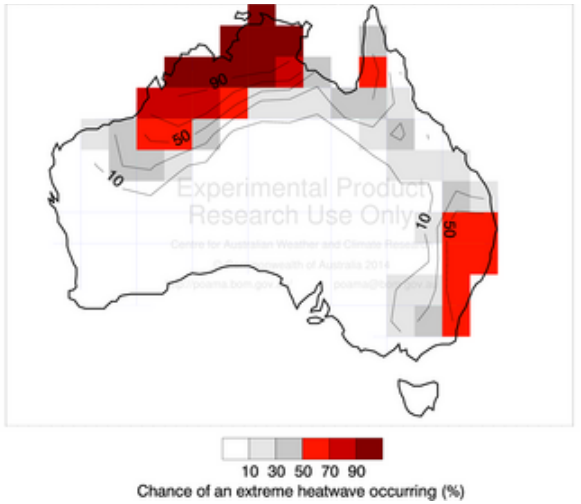
Low-intensity



Severe



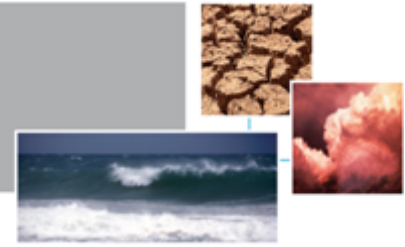
Extreme



Product also available for Weeks (2,3), Fortnights (1, 1.5, 2) and Month 1

poama.bom.gov.au

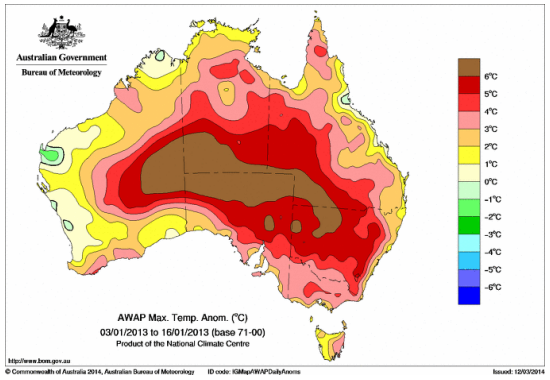
Percentile-based forecast products, e.g. January 2013



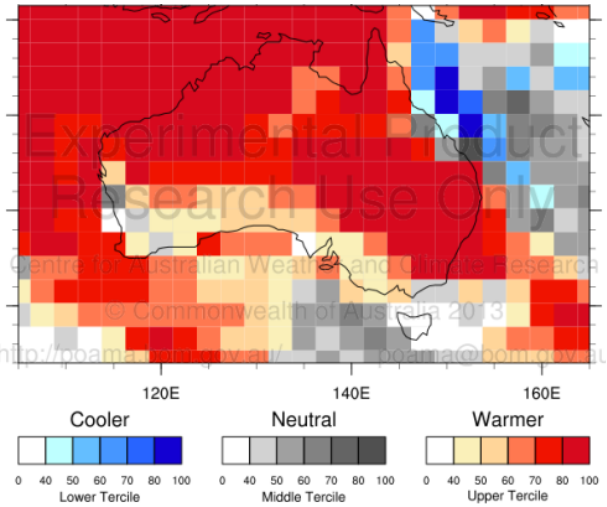
POAMA Tmax probability forecasts for the fortnight 3-16 January 2013

Weeks 2 and 3 (Initialised 27 December 2012)

OBSERVED (AWAP)

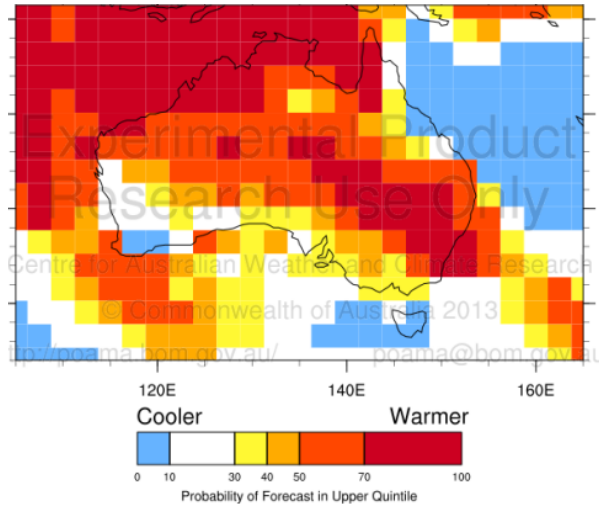


Tercile



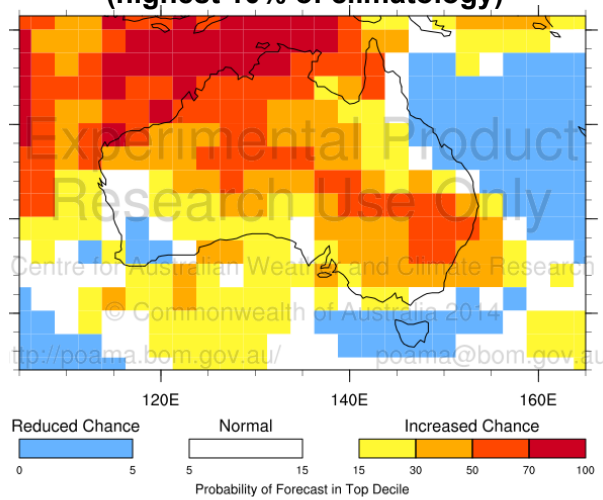
Upper Quintile

(highest 20% of climatology)



Upper Decile

(highest 10% of climatology)



Products available for Weeks (1, 2), Fortnights (1, 1.5, 2), Months (1, 2, 3) and Seasons (1, 2, 3)

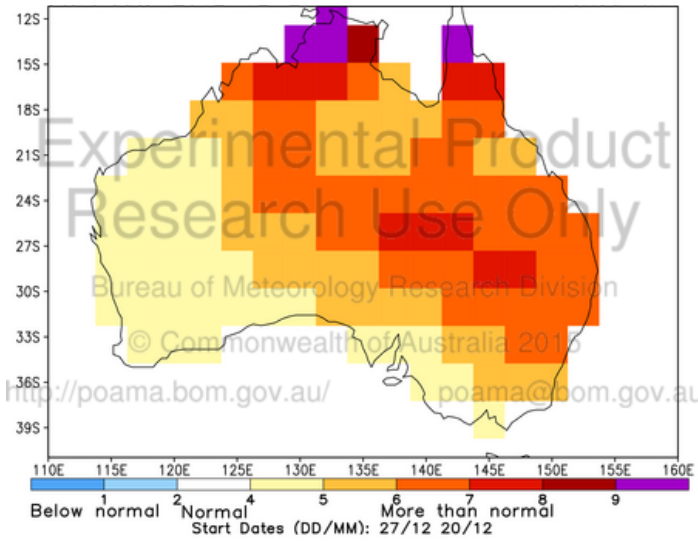
poama.bom.gov.au

Percentile-based forecast products, e.g. January 2013

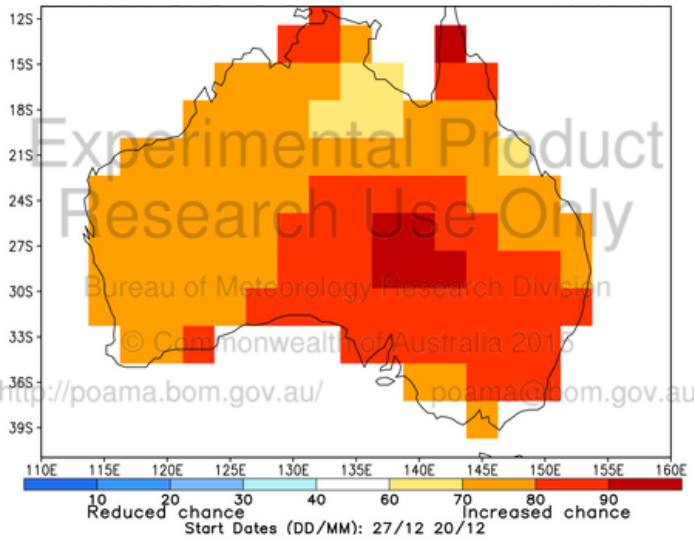
POAMA Extreme Heat Days forecast for January 2013

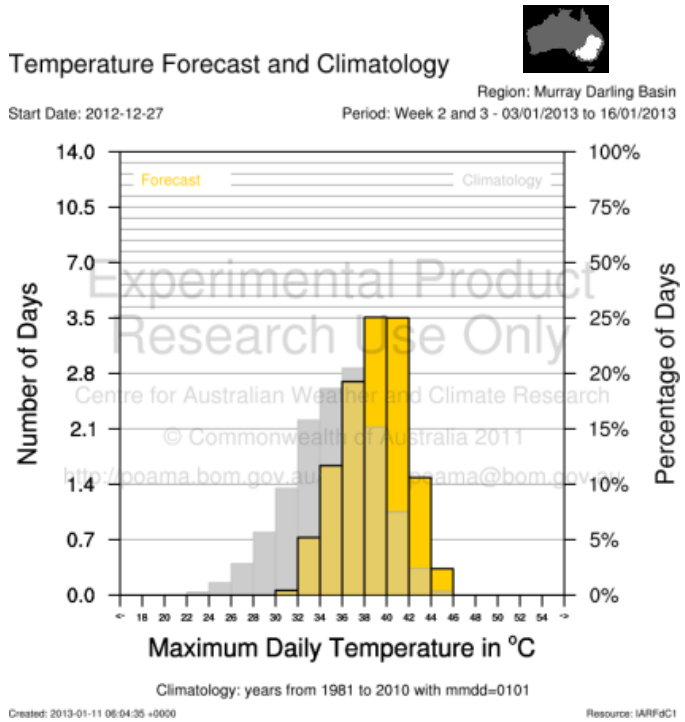
Month 1 (Initialised 27 December 2012)

Number of hot (decile 10) days



Chance of having more than the usual number of hot days





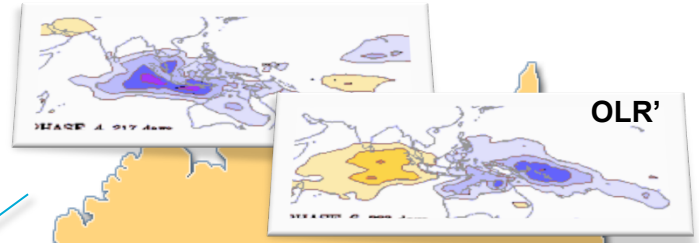
Product available for Months (1, 2, 3) and Season 1

poama.bom.gov.au

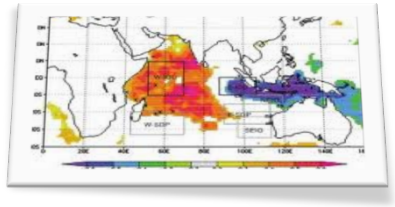
Predicted Tmax distribution (yellow) is shifted about +4°C, relative to climatology (grey)

Relationships with climate drivers: windows of forecast opportunity

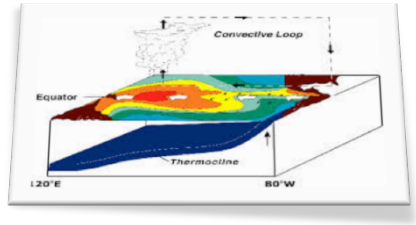
MJO



IOD

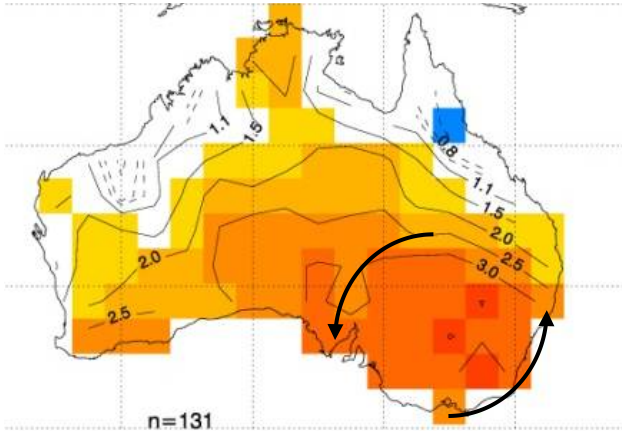


ENSO



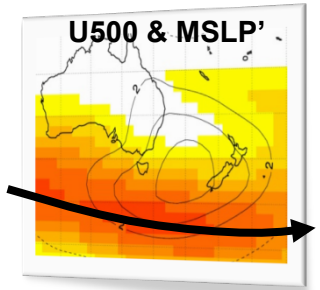
Drivers providing subseasonal predictability for extreme heat

E.g. MJO phase 3 in SON

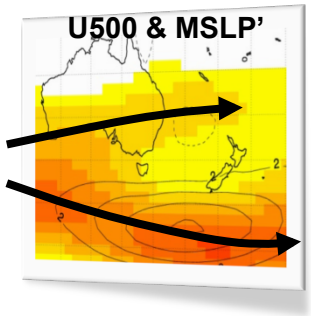


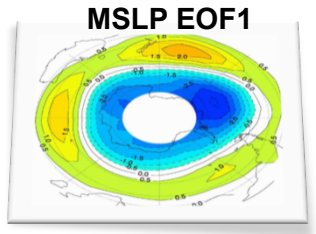
Marshall et al. (2014)
Clim Dyn, 43:1915-1937

STR high
H
(Tasman)



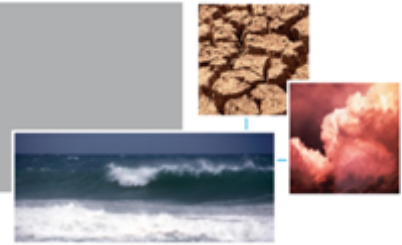
Split-flow
H
blocking





SAM

Conclusions

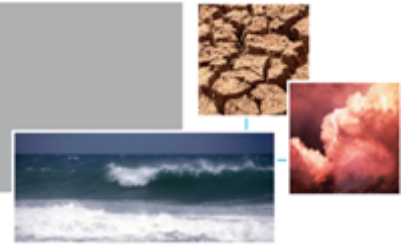


There is significant potential to augment traditional weather forecast warnings for heatwaves to include guidance on longer timescales

Understanding the capability of the forecast system for predicting subseasonal extremes underpins the potential future delivery of appropriate forecast products

Thank you

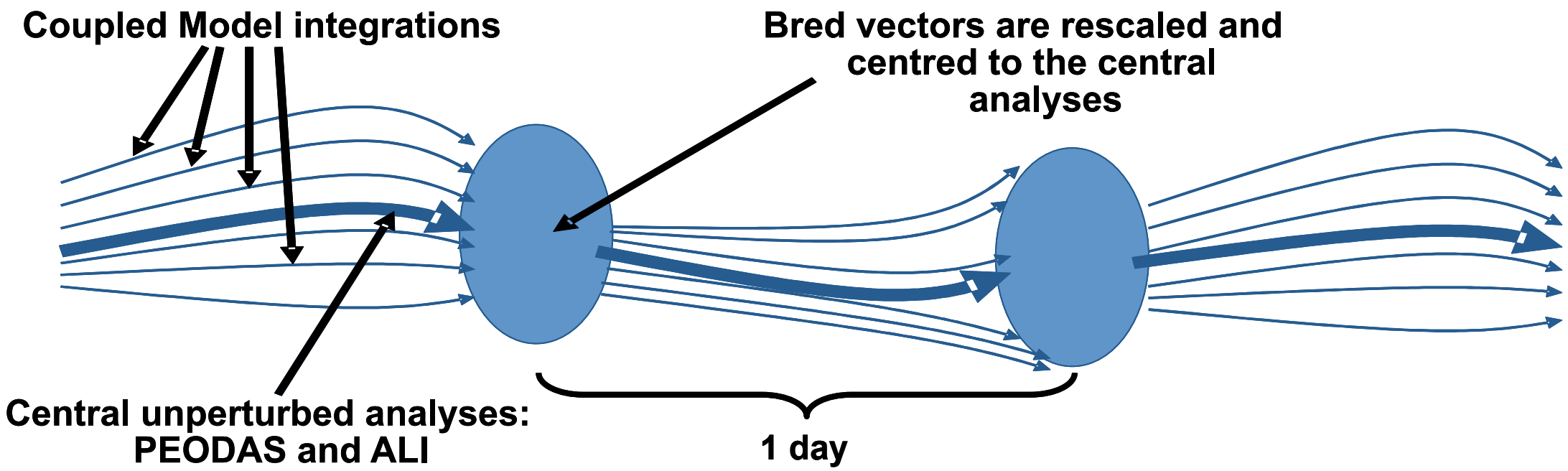
andrew.marshall@bom.gov.au



Towards Coupled Assimilation...

Based on the PEODAS infrastructure

Coupled Ensemble Initialisation System

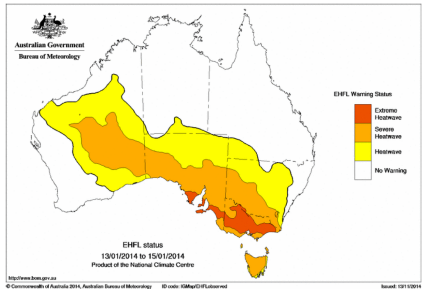


Generates coupled perturbations of the atmosphere and ocean based on a breeding method

Application to subseasonal heatwave forecasts, e.g. January 2014

Example: January 2014

One of the most significant multi-day heatwaves on record affected southeast Australia over the period from 13 to 18 January 2014.

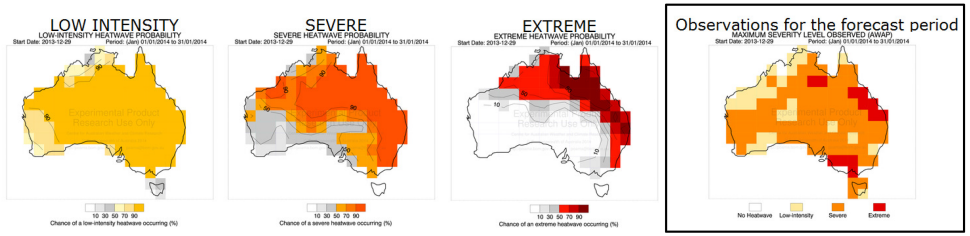


Observations for 13 to 15 January 2014

POAMA Forecasts (chance of a heatwave occurring in the period)

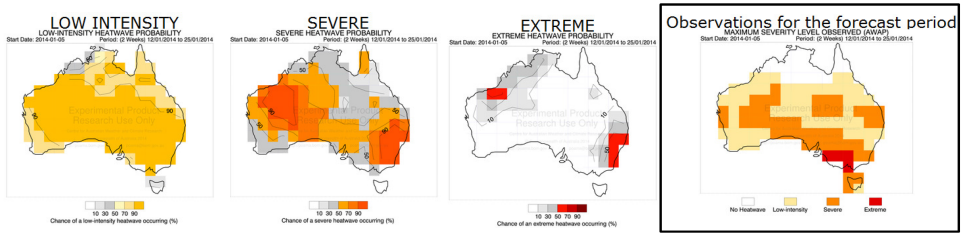
Forecast start date on ***29 December*** 2013 for the month of ***January***

READY



Forecast start date ***5 January*** 2014 for ***12 to 25 January*** (i.e. weeks 2 & 3)

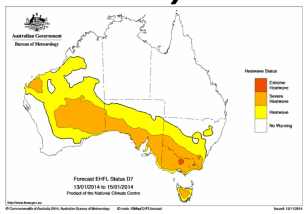
SET



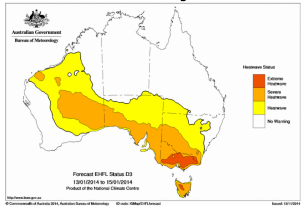
*Weather (NWP) Forecasts for **13 to 15 January***

GO

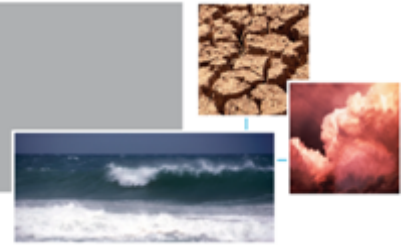
*Forecast start date **8 January** 2014*



*Forecast start date **12 January** 2014*



Percentile heat threshold products (tercile, quintile, decile)



Weekly-mean temperature anomalies in highest decile (above the 90th percentile; highest 10% of climatology)

Upper decile thresholds for calculating probability composites (AWAP)